Fundación Ecuatoriana para el Estudio de Mamíferos Marinos (FEMM)

THE GALAPAGOS HUMPBACK WHALES EXPEDITION
(31 August - 10 September 2005)

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FINAL REPORT TO:

The Whale and Dolphin Conservation Society (England)
The Frederick and Margaret L. Weyerhaeuser Foundation (USA)
Ecociencia (Ecuador)
Galapagos National Park (Ecuador)
Undersecretary of Coastal Environmental Management (Ecuador)

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CONTAINS

1. INTRODUCTION

In 1990, the waters of the Marine Reserve of Galapagos were declared as "Whale Sanctuary" by the Ecuadorian Government through the Ministerial Decree N° 196 (Ministry of Industries, Commerce, Integration and Fishing). Such status aimed at the protection of whales from human activities and at supporting the global moratorium issued by the International Whaling Commission in 1986, while creating new opportunities for scientific research. However, with the exception of the studies carried out by Dr. Hal Whitehead and collaborators (*e.g*. Whitehead, 1987; Whitehead and Rendell. 2004) and expeditions "*Siben*" (1988-1989) and "*Odyssey*" (1994 and 2000), all of which focused on Galapagos sperm whales (*Physeter macrocephalus*), no study has been carried out on any of the six baleen whales inhabiting Galapagos waters.

Researchers of the Ecuadorian Foundation for the Study of Marine Mammals (FEMM) conducted the expedition "Galapagos Humpback Whales" between 31 August and 10 September 2005. The study was made in the context of a long-term investigation of the Southeast Pacific humpback whale (*Megaptera novaeangliae*) stock that FEMM has been conducting on the coast of Ecuador since 1991 (see Félix and Haase, 2001, 2005). It obeys to the necessity of generating basic information from other areas of the breeding grounds that could be considered critical for this species. The characterization of critical habitats has been considered a key aspect of a regional conservation strategy recently designed for the Southeast humpback whale population (Flórez-González, *et al*., in press); therefore, this research also constitutes an important step forward in its implementation.

The main objective of this study was to establish the identity and status of the humpback whales that occur in the Galapagos archipelago through photographic, acoustic and molecular studies in order to create a knowledge baseline for management purposes. Other objectives included:

- To learn basic aspects of the Galapagos humpback whale population such as distribution, habitat use and relative abundance.
- To establish the phylogenetic relationship between the Galapagos and continental humpback whales through molecular biology studies.
- To obtain information for comparative studies on behavior, group structure, among others, between Galapagos and continental whales.
- To propose management measures for Galapagos humpback whales.

During the expedition other species of cetaceans as well as relevant aspects of seabirds were also recorded.

This study was authorized on 3 December 2004 by the Undersecretary of the Environment in Guayaquil, Ecuador, through letter No 000544 SGAC-MA/04 and the endorsement through letter No. 000543 SGAC-MA/04. Additionally, the Galapagos National Park issued the authorization Nº PC-13-05 on 18 July 2005 and the authorization to export samples from Galapagos through authorization Nº 080/05 PNG of 2 September 2005.

2. JUSTIFICATION

Despite the existence of confirmed observations of humpback whales in the Galapagos Islands which were used as background for this expedition (*e.g*. Day, 1995; Merlen, 1995, Palacios and Salazar, 2002), and some registered with photographs taken by naturalist guides, the low number of records indicated that the humpback whale was not a common species in waters of the archipelago. Such few records could be due not only to a lack of research but also to a potentially small population. If the latter is the case, determining the

phylogenetic relationship with continental whales would be of extreme importance for the survivorship of Galapagos humpback whales; a small and reproductively isolated population would require more stringent management measures.

Since the presence of humpback whales in Galapagos coincides with the breeding season of southern hemisphere whales, it likely that they belong to a southern stock. However, it was not possible to know if Galapagos humpback whales belong to the continental stock or if they form a discrete breeding unit. Also, there was no information on the number of humpback whales inhabiting the archipelago nor on the sites where they are distributed. Furthermore, there are no records between the coast of Ecuador and the Galapagos islands west of 83°21'W (Félix and Haase, 2005), which suggests either a scarce interchange of individuals with the continent or that Galapagos humpback whales take a different migratory route further offshore than coastal whales.

This study constitutes the first effort focused on humpback whales ever made in the Galapagos Islands. Here we present the most relevant results and provide some recommendations to local authorities in terms of conservation and management.

The Galapagos archipelago.

The Galapagos archipelago is formed by a group of 13 major islands and around 50 small islands and rocks of volcanic origin. It is located 1,000km west of the coast of Ecuador, South America (01°S, 91°W) (Figure 1). Its highly productive waters, especially on the western side, create favorable conditions for a high diversity of marine mammals, among them the humpback whale (Palacios and Salazar, 2002). The islands are surrounded by narrow shelves and abrupt slopes. There are some shallow areas in the central part of the archipelago, but in the outer part depth increases rapidly up to 3,000m or more, particularly on its western and southern sides.

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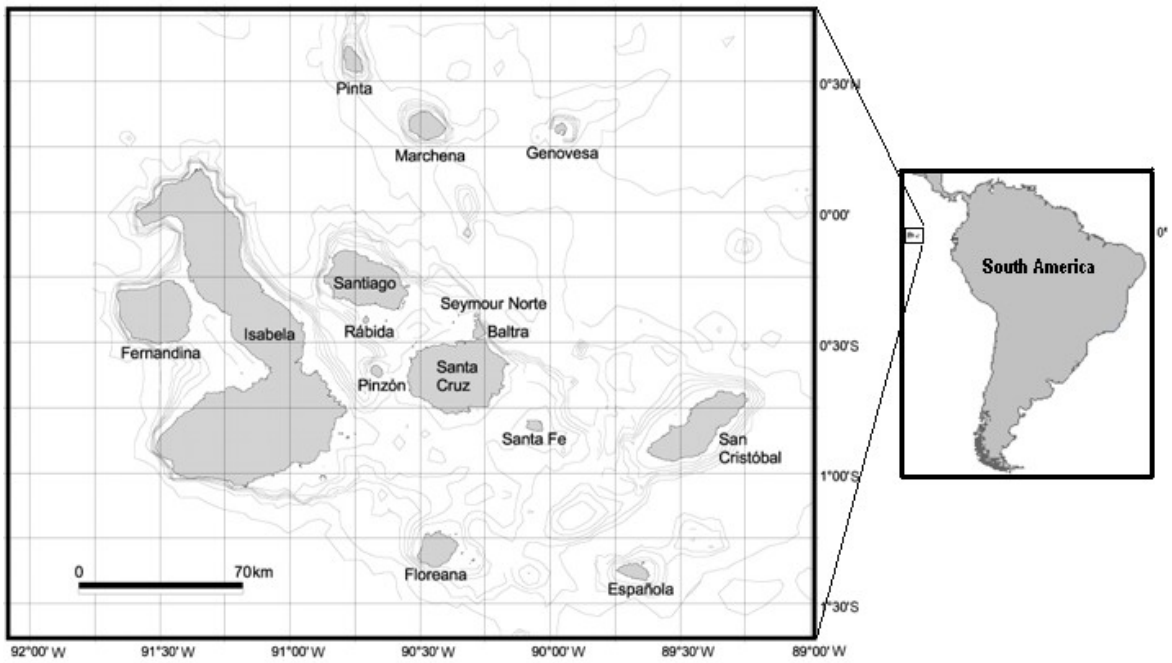

Figure 1. The Galapagos archipelago.

3. STUDIES AND RESULTS

During the study period, ten surveys were conducted in the central part of the archipelago aboard four different vessels: three boats with outboard engines (6-8m in length) and a 7-day

trip aboard the 12m sailboat "*Bronzewing*". Trips lasted between 5 and 12 hours depending on climate conditions and on finding a safe place to overnight. Surveys were carried out over the shelf of the islands in sites were the presence of humpback whales was reported by Merlen (1995). Surveys were planned the night before according to the progress made on that day. For this purpose the navigation Chart[1] I.O.A. 21 and a GPS Garmin 60 were used. In the case of boats with outboard engines, observers worked on the cabin's roof, at approximately 2-2.5m over the waterline. Boats moved at an average speed of 12kt. On the sailboat, which was powered by a small diesel inboard engine, observers were located on the main deck, both in the front and mid part of the vessel at an average height of 1.5m over the waterline. The sailboat's speed ranged between 5 and 7kt.

The surveyed areas covered waters around the following islands: west and north of San Cristobal; east and north of Santa Fe; north of Floreana; southeast of Isabela; north, west and south of Santa Cruz; southeast of Santiago; and the waters between them (Figure 1). The total distance covered was 722.36km and the total navigation time was 81 hours and 20 minutes (Table 1).

Figure 2. Track of the surveys in the Galapagos archipelago, 31 August- 10 September 2005.

Table 1. Details of the surveys inside the Galapagos archipelago, 31 August- 10 September 2005.

Date	Survey	Time	Distance (km)
31/08/05	West and northwest sides of San Cristóbal.	7 h 54 min	100.5
1/09/05	San Cristóbal-Santa Fe-Santa Cruz	6 h 11 min	74.5
3/09/05	Santa Cruz-Santa Fe	5 h 13 min	38.6
4/09/05	Santa Fe-Floreana	9 h 15 min	72.5
5/09/05	Floreana-Southeast of Isabela	11 h 50 min	91.39
6/09/05	Southeast of Isabela-Rábida	11 h 29 m	72.28
7/09/05	Rábida-Baltra	10 h 8 min	58.61
8/09/05	Baltra-east of Santa Cruz	6 h 13 min	37.63
9/09/05	East of Santa Cruz-Puerto Ayora	7 h 43 min	93.99
10/09/05	Santa Cruz-San Cristóbal	5 h 24 min	82.36
TOTAL		81 h 20 min	722.36

[1] The navigation chart is produced by the Oceanographic Institute of the Navy of Ecuador (INOCAR).

3.1. The humpback whale

The only humpback whale observation done during the expedition was recorded at Santa Fe Island (0º47.6'S, 90º05.1'W). The group was made up by a mother with a small calf, probably a few weeks old (Figure 3). This record confirms that the species use Galapagos waters for calving and nursing. The pair was found over a shallow area of less than 20m in depth in the northern part of the island. According to the navigation chart I.O.A. 21, Santa Fe Island has a shelf of 100m in depth extending some 10km on its southeast side, but in the northern part, where the pair was found, the shelf extends approximately 3km. The sighting was made exactly over a flat marked on the map with 13m in depth and with an area of 3-4km^2 approximately.

Considering the surveyed distance, the encounter rate of humpback whales in Galapagos in this expedition was of 0.276 whales/100km of survey.

Figure 3. Mother and calf humpback whales photographed at Santa Fe Island, the only group of this species recorded during the expedition.

Photo-identification. From the adult whale at Santa Fe, it was only possible to take photos of the back with dorsal fin. Photos were taken with a Canon Rebel Digital (6.3 megapixels) camera with a 70-300mm. Zoom lens. It was not possible to take photos of the ventral side of the flukes since, as occurs with continental whales, females with calves usually do not raise the tail in shallow waters. Available photos are being compared with dorsal fins of continental whales from the FEMM catalogue looking for a match.

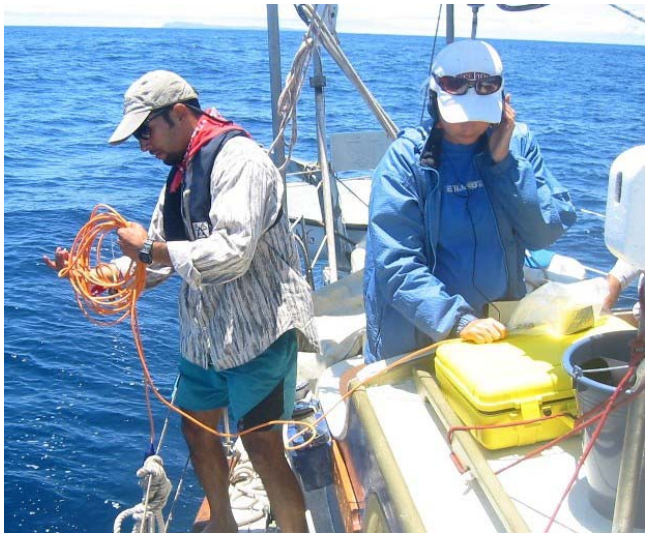

Figure 4. Deploying the hydrophone into the water.

Acoustic. A hydrophone model C10 (Cetacean Research Technology) with a response frequency between 0.25 y 25 kHz and a digital voice recording Archos G-Mini 120 were used for listening and recording whale sounds (Figure 4). The

hydrophone was used on an irregular basis, in some cases after 60 minutes of survey, especially when boats with outboard engines were used. On board the sailing boat the hydrophone was used sporadically at the beginning and end of the surveys. The hydrophone was dropped for at least five minutes in 25 different sites but no sounds were heard during the entire survey. The lack of male whale sounds confirmed that the density of breeding humpback whales must be low. Figure 4 shows a map of the sites of the stations were the hydrophone was launched. Table 2 shows the geographic position of the stations.

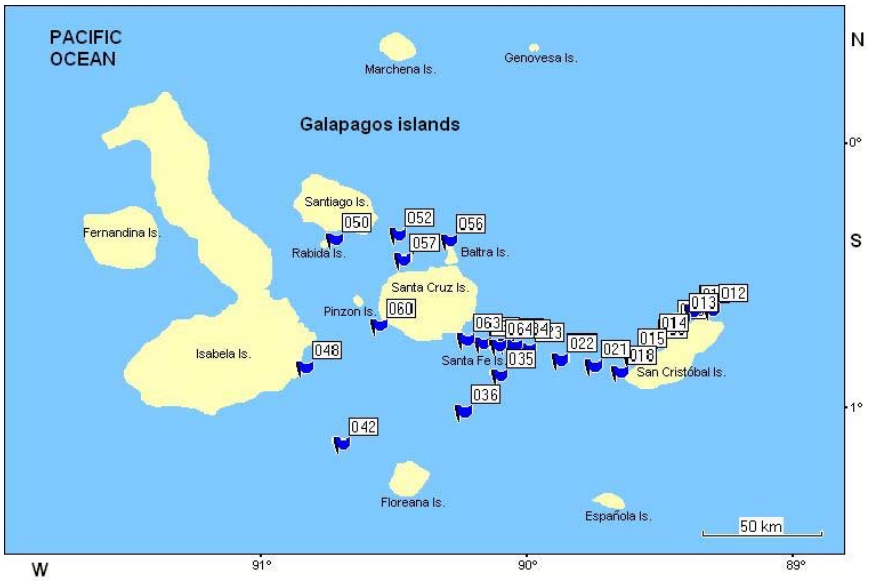

Figure 4. Sites of the archipelago where the hydrophone was deployed for listening to the whales. Blue flags show the sites of the stations and the numbers the waypoint recorded in the GPS.

Table 2. Details of the 25 stations where the hydrophone was deployed into the water.

Station No.	Date	Hour	Position
9	31/8/2005	11:42	0º48.070'S, 89º31.477'W
10	31/8/2005	12:42	0º43.570'S, 89º26.997'W
11	31/8/2005	13:44	0º40.104'S, 89º22.011'W
12	31/8/2005	14:41	0º39.815'S, 89º17.531'W
13	31/8/2005	15:42	0º42.116'S, 89º24.433'W
14	31/8/2005	16:54	0º46.628'S, 89º31.078'W
15	31/8/2005	17:56	0º50.027'S, 89º35.922'W
18	1/9/2005	11:04	0º53.902'S, 89º38.316'W
21	1/9/2005	12:01	0º52.546'S, 89º44.442'W
22	1/9/2005	12:57	0º51.105'S, 89º 51.847'W
23	1/9/2005	13:57	0º48.873'S, 89º 59.196'W
24	1/9/2005	15:09	0º47.688'S, 90º03.958'W
30	1/9/2005	17:10	0º47.525'S, 90º09.461'W
34	3/9/2005	18:43	0º48.070'S, 90º02.280'W
35	4/9/2005	10:53	0º54.674'S, 90º05.522'W
36	4/9/2005	13:24	1º02.694'S, 90º13.836'W
42	5/9/2005	14:34	1º09.951'S, 90º41.250'W
48	6/9/2005	14:36	0º52.664'S, 90º49.509'W
50	7/9/2005	7:58	0º23.977'S, 90º42.719'W
52	7/9/2005	11:49	0º22.986'S, 90º28.565'W
56	8/9/2005	9:04	0º24.207'S, 90º16.882'W
57	8/9/2005	12:04	0º28.412'S, 90º27.403'W
60	9/9/2005	10:14	0º43.254'S, 90º32.917'W
63	10/9/2005	9:04	0º46.702'S, 90º13.177'W
64	10/9/2005	10:18	0º48.080'S 90º05.862'W

Molecular Biology. From the adult humpback whale a skin biopsy 5cm in length was taken with a Barnett crossbow and arrows 60cm long and with modified tips (Figure 5) (see Lambertsen, 1987). The sample was preserved in a solution of DMSO (dimetilsulfoxide) saturated of NaCl (sodium chloride). Data on sampling procedure, type of animal and the reaction of the whale was recorded in a biopsying data form during the process. Additionally, other six skin samples obtained from beached whales between 1992 and 2005 on mainland Ecuador were used for comparison in a mitochondrial DNA study (Table 3). Such samples were preserved at the time in 50% alcohol

Figure 5. Skin biopsy from the female humpback whale.

Mitochondrial DNA was extracted from the samples using a standard protocol based on phenol-chloroform. A variable portion of the control region was amplified by PCR procedure according to the methodology used by Baker *et al*. (1998). Four samples from mainland Ecuador and the Galapagos could be amplified. A consensus portion of the control region was sequenced and compared with sequences obtained in a molecular characterization study made in Colombian humpback whales (Caballero *et al*., 2001) and in other sites of the Southern Hemisphere (Baker *et al*., 1998). Four different haplotypes defined by 72 variable sites that have not been recorded in other Southern Hemisphere populations except in Southeast Pacific humpback whales were found in the five samples. Samples 5 and 6 shared the same haplotype, which is the most common in the Southeast Pacific. Samples 2 and 7 (Galapagos) have haplotypes found in Colombian whales but in a low proportion and sample 3 showed a different haplotype not recorded before in Colombia.

Table 3. Information about the samples used in the molecular biology study.

No. Sample	Site	Position	Date of collection	Sex	Length (m)
1	Ancón	2º19'S, 80º51'W	8-Sep-1994	M	7.25
2	Playas	2º37'S, 80º23'W	9-Sep-2002	H	5.45
3	Playas	2º37'S, 80º23'W	9-Sep-2002	H	16.2
4	Data de Posorja	2º42'S, 80º14'W	25-Ago-2004	H	14.5
5	La Rinconada	1º43'S, 80º48'W	19-Ago-2004	M	14.3
6	Mar Bravo	2º13'S, 80º59'W	30-Ago-2005	M	6.4
7	Galápagos	0º47'S, 90º05'W	1-Sep-2005	H	>14

3.2. Other cetaceans recorded

Other three species of cetaceans were also recorded during the expedition: an unidentified rorqual (*Balaenoptera* sp), the common dolphin (*Delphinus delphis*) and the bottlenose dolphin (*Tursiops truncatus*) (Figure 6). For the two cases referred to as unidentified rorquals, the most probable identification is minke whales *B. acutorostrata*. This is concluded based on the following reasons: 1) their small size (8-12 m); 2) presence of a whitish strip behind the head known as "chevron" in both recorded groups, a feature only present in two species of rorquals: fin whales (*B. physalus*) and minke whales; and 3) white-colored mandibles on the whales seen at short distance on 4 September. Fin whales were excluded as identity for these whales because the small size and because the form of the dorsal fin. However, since not much is known about the coloration of Mysticeti whales in Galapagos, it

can not ruled out that the recorded animals were sei whales (*B. borealis*). The position of the sighting and the number of individuals present in each group is given in Table 4.

In the case of the bottlenose dolphins, photographs of their dorsal fins were taken for individual identification. A catalogue with 6 identified dolphins has been started which will be useful for future studies of this population. A skin biopsy from one individual was also taken for molecular studies.

Figure 6. Species of cetaceans recorded during the expedition: unidentified rorqual (above), common dolphin (left below) and bottlenose dolphin (right below).

Table 4. Data on other species of cetaceans recorded during the expedition.

Common name	Scientific name	Date	Position	Group size
Bottlenose dolphin	*Tursiops truncatus*	1/09/05	0º52.9'S, 89º41.8'W	2
Unidentified Rorqual	*Balaenoptera* sp	4/09/05	0º22.5'S, 90º32.1'W	2
Unidentified Rorqual	*Balaenoptera* sp	5/09/05	1º09.9'S, 90º41.3'W	2
Common dolphin	*Delphinus delphis*	5/09/05	1º06.5'S, 91º00.3'W	100-150
Bottlenose dolphin	*Tursiops truncatus*	7/09/05	0º22.5'S, 90º32.1'W	10-20
Bottlenose dolphin	*Tursiops truncatus*	10/09/05	0º50.2'S, 89º51.0'W	20-30

3.3. *Seabirds recorded*

During our search for cetaceans special attention was also paid to the birds (Figure 5). Besides the commonly observed seabird species there were no new findings, but for the following species it could be worth making these comments:

Pterodroma phaeopygia - Dark-rumped Petrel.

They were seen on almost every crossing or near the islands where we stayed anchored or passed by. Concentrations of dozens of birds were observed off southwest Isabela, Santa Fe, Santa Cruz and along the northwest coast of San Cristobal.

Oceanodroma markhami/melania - Markham´s Stormpetrel and Black Stormpetrel
A larger all brown stormpetrel was observed on 1 September between San Cristobal and Santa Fe. Short observation time and distance made it impossible to identify to one of these two similar species.

Phaethon aethereus – Red-billed Tropicbird
Commonly observed between the islands and near breeding colonies along cliffs. A concentration of at least 11 birds was observed around Daphne Minor on the 7 September.

Sula sula – Red-footed Booby
A flock of 300 to 400 feeding boobies was observed near Las Cuevas on Floreana on 4 September. There were at least 50, maybe up to 100 Red-footed boobies of both color morphs joining Nazca and blue-footed boobies.

Phalaropus lobatus – Red-necked Phalarope
This was probably the most numerous species during the survey. A few individuals were seen in the calm waters north of Santa Cruz and Santa Fe, but flocks of sometimes more than a thousand birds were found in upwelling areas or where currents mixed. No exact counts were made, but the total number of observed birds must be around 40,000 to 50,000 birds. Many were seen flying in a southerly direction, and it is not clear what percentage of the birds stays for the winter. This will be important to know for future studies in the region, because the species' population is known to be decreasing.

Phalaropus fulicarius Red Phalarope
This species is far less common than the Red-necked Phalarope. Identification at sea is difficult, and usually only can be done when the birds pass by at close range. Many phalaropes were observed at short distance from the bow, but most mostly the Red-necked, and in about seven or eight occasions good view allowed the identification of the Red Phalarope (some of which were confirmed by photographs).

(N.B.: On a visit to Dragon Hill (Santa Cruz Island) on 26th August, 2 Wilson´s Phalarope *Phalaropus tricolor* were observed in a lagoon. Interestingly, this species has never been seen resting on the sea during many cruises done by the third author)

Figure 7. Some Galapagos seabirds: Red-billed Tropicbird, Red-footed Booby, Red-necked Phalarope.

4. DISCUSSION Y CONCLUSIONS

Results from this first expedition show that, in fact, there is a low density of humpback whales in the Galapagos Islands and they cannot be considered a common species, as was reported previously (*e.g*. Day, 1994; Merlen, 1995; Palacios and Salazar 2002). The density found in Galapagos was 59 times lower than that found off mainland Ecuador at Salinas during the same season by our team (Félix *et al*., 2005). However, it is important to mention that the low density of humpback whales seems to be common to oceanic archipelagoes in the South Pacific. In this regard, Gannier (2004) reported abundances between 0.35 and 1.54 whales/100km of survey in several archipelagoes of the French Polynesia. This is between 1.3 and 5.7 times higher than in Galapagos. It is also known that humpback whales show a cluster distribution in archipelagoes, with sites of high concentration of animals and extended zones with low density. In Hawaii, for example, there is a high density in a shallow area named the Penguin Bank and in an area surrounded by four islands in the central part of the Hawaiian chain (Darling, 2001). In the Caribbean, 85% of the entire population of the North Atlantic concentrates for breeding at Silver and Navidad Banks off the northern part of Dominican Republic, but humpback whales can distribute as far south as the Lesser Antilleans (Winn *et al*., 1975). It is not excluded that such type of distribution may occur at Galapagos, although it seems unlikely that in an area with a high tourism demand such a site has passed unnoticed. The use of aerial transects could help to locate sites of humpback whale concentration and should be considered as a valid option in future studies.

An important finding of this expedition is the confirmation that the Galapagos's is a breeding population. Therefore Galapagos Islands must be considered a breeding and calving zone for this species. Although there were already a few records involving mother/calf pairs (see Merlen, 1995), it is relevant to have obtained both photos and a skin sample. Mother and calf humpback whales in Galapagos seems to have preference for shallow waters near shore, at least during the first calving weeks, in a similar form as occurs in mainland Ecuador (Félix and Haase, 2005) and in other calving areas (*e.g.* Smultea, 1994; Vang, 2002; Ersts and Rosembaum, 2003). Such distribution has important conservation implications for the species due to the intense maritime traffic generated by tourism, the main economic activity in Galapagos. As a matter of fact, the mother and the calf were very shy, and were found on a very busy route just north of Santa Fe where fast launches with passengers passed on their way from east to west or back.

The molecular biology studies showed a relationship between Galápagos humpback whales and the Southeast Pacific stock as well as confirmed the existence of a high genetic variability in this stock, as reported in previous studies in Colombia (Caballero *et al*., 2001), southern Chile and the Antarctic Peninsula (Olavarría *et al*., 2005). The haplotype found in the Galapagos seems uncommon in continental whales since it was found only once in 144 Colombian samples. However, more samples from Galapagos are necessary to establish the degree of variability and which are the main lineages there, among other key population parameters. Interestingly, the haplotype found in continental sample 3 was not present in Colombian whales, suggesting that the structure of this stock is even more complex likely due to a heterogeneous distribution. Recently, a genetic differentiation has also been found between the whales feeding in southern of Chile and those feeding at the Antarctic Peninsula (Olavarría *et al*. 2005), indicating that the Southeastern humpback whale stock would consist of at least two well-defined breeding sub-units.

An operational aspect to take into consideration in future expeditions is the height of the observation post on board the boat. This is a critical aspect when cetaceans are studied in open waters. In Galapagos the research on southern humpback whales must be carried out in the windy season and therefore most days the sea is rough. The relatively low position of the observation point was probably the cause of the low number of sightings of other cetacean species during the expedition.

Besides the scientific interest, this work also has contributed to the knowledge of other species of cetaceans that may have a direct benefit for tourism activities. Similar studies could improve our knowledge of these species and help set up whalewatching programs as occurs in continental waters, benefiting with this to local communities in creating new working opportunities for artisanal fishermen.

5. RECOMMENDATIONS

1. Continue the research on humpback whales in Galapagos to obtain enough data in order to determine its population status, distribution, density and other population parameters.
2. Although the identity of the Galapagos humpback whales has been partially defined though mtDNA studies with one sample, it is necessary to get a larger number of samples to carry out a deeper and reliable comparison, as well as to establish the main lineages in the whales from the archipelago.
3. Galapagos humpback whale population seems to be small compared to continental whales and it possibly is a true population subunit, which is necessary to highlight in future biodiversity diagnostics.
4. Similar level of discreteness could also occur in other cetacean species in Galapagos. Therefore, it could be desirable to start a molecular characterization of the different populations inhabiting Galapagos waters.
5. Mother and calf pair humpback whales seem to have a similar distribution as occurs in continental waters and in other breeding sites; they prefer shallow waters close to the shore. Local authorities must inform tourist operators and vessels about the possible presence of humpback whales so that they take care when moving over the platform of the islands.
6. We encourage to National Park authorities and the Charles Darwin Station to support research initiatives on Galapagos cetaceans as developed by FEMM. Due to the high costs of the boats in Galapagos to carry out research at sea, vessels of the National Park could be used as research platforms during patrolling activities.
7. The low density of humpback whales in Galapagos contrasts with the density found along the mainland coast of Ecuador. Therefore, it seems unlikely to set up a successful whalewatching program exclusively for this species. However, Galapagos possess a high diversity of cetacean species with potential for tourism which deserves at least a feasibility study.

6. BUDGET

Details of the costs of this expedition are shown in Annex 1.

7. ACKNOWLEDGEMENTS

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ANNEX 1

Cost details.

INCOME:

Total income (US $)	**7,220.00**

EXPENSES:

ITEM	Quantity	Subtotal (US $)
Equipment:		
GPS 60	1	350
Hydrophone C10 (Cetacean Research Technology) and digital voice recording and pocket preamplifier.		641.36
Radios	2	43.09
Binocular	1	133.42
Memory cards 1Gb	2	220
Lodging and food:		
Hotel		224
Food		386.36
Materials:		
Oligonucleotids primers (including shipping)		102
Samples packing and shipping to New Zealand		37.66
Other materials		228.71
Boat charting (US $ 300.00/day)	10	3,000
Others (Crew sailing boat "*Bronzewing*")		100
Transportation		
Air tickets Guayaquil-Galápagos-Guayaquil (nationals)	3	540
Air ticket Guayaquil-Galápagos-Guayaquil (foreigner)	1	390.16
Sobrequipaje	1	42.87
Tickets boat transportation inside Galapagos US $30 (sea)	5	150
Transportation in Guayaquil and Galapagos (land)		50
Administration:		
Permit Ministry of the Environment	2	220
National Park tax (national)	3	18
National Park tax (foreigner)	1	100
Miscellaneous, paper, mail, phone, internet, banks, etc	1	240
Total costs (US $)		**7,217.63**